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When Paying Attention Becomes Counterproductive: Impact of Divided Versus Skill-Focused Attention on Novice and Experienced Performance of Sensorimotor Skills

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Two experiments examined the impact of attention on sensorimotor skills. In Experiment 1, experienced golfers putted under dual-task conditions designed to distract attention from putting and under skill-focused conditions that prompted attention to step-by-step putting performance. Dual-task condition putting was more accurate. In Experiment 2, right-footed novice and experienced soccer players dribbled through a slalom course under dual-task or skill-focused conditions. When using their dominant right foot, experts again performed better in the dual-task condition. However, when using their less proficient left foot, experts performed better in the skill-focused condition. Novices performed better under skill-focus regardless of foot. Whereas novices and the less-proficient performances of experts benefit from online attentional monitoring of step-by-step performance, high-level skill execution is harmed.

What drives the performance of a well-learned skill? Knowledge structures (Chi, Feltovich, & Glaser, 1981), memory capacities (Chase & Simon, 1973; de Groot, 1978; Starkes & Deakin, 1984), problem-solving abilities (Priest & Lindsay, 1992; Tenenbaum & Bar-Eli, 1993), and individual differences (Ackerman, 1987; Ackerman & Cianciolo, 2000; R. Kanfer & Ackerman, 1989) involved in high-level performance have been extensively examined, as well as compared across skill levels, in an attempt to shed light on the variables mediating exceptional task execution. Although work in this area has produced a number of important findings in both cognitive and sensorimotor skill domains (see Ericsson & Lehmann, 1996), there remain aspects of high-level performance that have not yet received adequate analysis.

One such area centers around the attentional mechanisms supporting skill execution in real time. That is, the manner in which experienced performers allocate attention to skill processes and procedures as actual skill execution unfolds, as well as differences in the attentional requirements of low- and high-level performances, are not yet fully understood. The purpose of the present study was twofold: (a) to assess the attentional mechanisms supporting performance of two sensorimotor skills in real time and (b) to explore the relationship between the attentional demands of online skill execution and degree of task proficiency. This knowledge will not only aid in developing the most appropriate techniques for optimal skill acquisition (Singer, Lidor, & Cauraugh, 1993; Wulf, Hob, & Prinz, 1998; Wulf, McNevin, Fuchs, Ritter, & Toole, 2000) but may also help to explain the suboptimal performance of well-learned skills in situations such as high-pressure environments thought to stress attentional capacity or interfere with its effective deployment (Baumeister, 1984; Beilock & Carr, 2001; Lewis & Linder, 1997).

Attention and the Proceduralization of Skill

Skill acquisition is believed to progress through distinct phases characterized by both qualitative differences in the cognitive structures supporting performance and differences in performance itself. Researchers have proposed that early in learning, skill execution is supported by a set of unintegrated control structures that are held in working memory and attended to one-by-one in a step-by-step fashion (Anderson, 1983, 1993; Fitts & Posner, 1967; Proctor & Dutta, 1995). As a result, attention is committed to controlling task performance and hence is largely unavailable for the interpretation or processing of nontask-related stimuli. With practice, however, procedural knowledge specific to the task at hand develops. Procedural knowledge does not require constant control and operates largely outside of working memory (Anderson, 1993; Fitts & Posner, 1967; Keele & Summers, 1976; Kimble & Perlmuter, 1970; Langer & Imber, 1979). Thus, in contrast to earlier stages of performance, once a skill becomes relatively well learned, attention may not be needed for the step-by-step control of execution and may be available for the processing of extraneous stimuli.

The impact of secondary task demands on novel skill acquisition and performance, as well as the ability of high-level performers to successfully operate in environments with substantial attentional load, have been widely demonstrated. Nissen and Bullemer (1987) examined individuals' performance on a novel sequence-learning task under both single-task and dual-task conditions. The sequence task was a four-choice reaction time task in which stimuli were

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presented in a consistent pattern in one of four locations on a computer screen. Participants were instructed to respond to the presentation of each stimulus by pressing a key at a corresponding spatial location. In the single-task condition, individuals practiced the sequence in isolation. In the dual-task condition, participants practiced the sequence while performing an attention-demanding, secondary auditory-monitoring task. In contrast to the single-task sequence condition, individuals performing under added secondary task demands showed no evidence of sequence learning during performance in the dual-task situation or during a transfer test in which individuals received the same sequence in isolation. Subsequent work by A. Cohen, Ivry, and Keele (1990) showed that the severity of the dual-task decrement in sequence learning varied with the complexity of the sequential pattern. These findings suggest that at the initial stages of performance, attention may be a necessary ingredient of skill learning, and the more so the more complicated the skill.

Although attention to task components may be important for novel skill execution and learning, this may not be the case at higher levels of practice. Allport, Antonis, and Reynolds (1972) found support for this notion through the examination of skilled pianists' ability to sight-read music while performing a secondary auditory-monitoring task. When skilled pianists were asked to sight-read in addition to shadowing a series of auditorially presented words, their sight-reading performance was not significantly altered in comparison with sight-reading in isolation. Allport et al. suggested that well-learned sight-reading does not demand constant attentional control. As a result, attention is available to devote to secondary task demands without significantly disrupting primary task performance.

Fisk and Schneider (1984) have also argued that well-learned performances are not based on explicit attentional control mechanisms. Individuals were trained on a visual search task in which they learned to search through arrays of visually presented words for members of a target category. With practice, both reaction time and accuracy in finding targets increased, whereas recognition memory for the words that had been searched through declined in comparison with memory at lower levels of practice. Fisk and Schneider suggested that practice automated performance, and automating performance improved real-time skill execution while decreasing attention to specific task components.

Thus, novel and well-learned performances appear to require different levels of attentional resources for successful execution. This experience by attentional demand interaction has also been demonstrated in complex sensorimotor skills drawn from the real world. For example, Leavitt (1979) examined novice and experienced ice hockey players' ability to complete a hockey task while performing a secondary visual shape-identification task. Individuals were required to skate and stick-handle a puck through a slalom course of pylons in isolation and while performing a monitoring task in which they identified geometric shapes projected onto a screen they could see from the ice. Leavitt found that the addition of the secondary visual shape-identification task to the primary skating-and-stick-handling task did not affect experienced hockey players' skating and stick-handling performance. However, when novices were required to perform the primary skating-and-stick-handling task in addition to the secondary monitoring task, their performance on the primary task declined markedly in comparison with skating and stick handling in isolation. In a similar study, Smith and Chamberlin (1992) also found differences across skill levels in performers' abilities to attend to multiple tasks simultaneously. Experienced and less skilled soccer players dribbled a soccer ball through a series of cones set up on a gymnasium floor. Individuals dribbled in isolation or while performing a secondary visual-monitoring task similar to that used in Leavitt's study mentioned above. Adding the secondary task harmed the dribbling of less skilled players in comparison with dribbling in isolation but did not significantly affect experienced soccer players' dribbling performance.

The results of Leavitt (1979) and Smith and Chamberlin (1992) support the notion that well-learned skill performance does not require constant online attentional control. However, it should be noted that these findings are potentially confounded. The secondary tasks used in the hockey and soccer tasks were both in the visual modality. Low-skill players often spend a considerable amount of time looking down at the puck or the ball while performing these skills. Thus, skill level differences in these studies may not have been due to experts' more automated control processes per se but instead may have been the result of less skilled individuals' higher need for visual information and feedback from the objects they were attempting to manipulate (i.e., a hockey puck or soccer ball). In essence, differences in "structural interference" (Kahneman, 1973; Wickens, 1980, 1984), rather than differential demands of novice and experienced skill performance on attention, may have led to the above mentioned findings. For novices, both the primary task of stick handling or dribbling and the secondary visual-monitoring task require visual input, and the information-gathering structures of the visual system cannot be directed toward both the primary and secondary tasks' stimuli simultaneously. Hence, the two tasks compete for visual information. This means that novice task performance under dual-task conditions may have suffered as a result of structural interference, whereas experienced individuals' performance, which presumably does not demand constant visual contact with the objects under control, did not.

Recently, Beilock, Wierenga, and Carr (in press a, b) addressed this confound in the exploration of the attentional mechanisms governing novice and well-learned golf putting. Novice and experienced golfers took a series of golf putts in a single-task putting condition (involving putting in a quiet, isolated environment) and in a dual-task condition. In the dual-task condition, individuals putted while monitoring verbally presented words for a specified target word. Because auditory capacity should not differ as a function of golf-putting experience, and auditory input should not create structural interference with the visual input of putting, this secondary task was designed to be free of the confound present in Leavitt (1979) and Smith and Chamberlin's (1992) work. Results demonstrated that experienced golfers' putting accuracy was not affected by the addition of the secondary monitoring task, in comparison with single-task putting. Furthermore, when experienced golfers were given an unexpected recognition memory test for a subset of the words contained in the monitoring task, their performance did not differ from a single-task word recognition test given as a baseline measure. Because attention is known to influence recognition memory (Craik, Govini, Naveh-Benjamin, & Anderson, 1996), this result indicates that experienced golfers were able to pay just as much attention to the words while putting as when attending to the words was their only task, and that doing so did not harm their putting performance. In contrast, novice golfers showed both putting and word recognition decrements from single- to dual-task conditions. Consistent with Leavitt and Smith and Chamberlin, Beilock et al. (in press a, b) concluded that expertise leads to the encoding of task components in a proceduralized form that supports effective real-time performance, without the need for constant online attentional control.

When Attention to Performance May Be Counterproductive

Well-learned skills do not appear to require constant attentional control during execution. However, the notion that these skills are based on a proceduralized or "automated" representation carries even stronger implications for attending to practiced performances. Researchers have proposed that attending to the step-by-step component processes of a proceduralized skill may actually disrupt execution (Baumeister, 1984; Beilock & Carr, 2001; Kimble & Perlmuter, 1970; Langer & Imber, 1979; Lewis & Linder, 1997). Therefore, attention to performance may become counterproductive as practice builds an increasingly automated performance repertoire. Masters and colleagues (Masters, 1992; Masters, Polman, & Hammond, 1993) proposed that attention to high-level skills results in their "breakdown," in which the compiled real-time control structure of a skill is broken down into a sequence of smaller, separate, independent units—similar to how performance may have been organized early in learning. Once broken down, each unit must be activated and run separately, which slows performance and, at each transition between units, creates an opportunity for error that was not present in the "chunked" control structure. Researchers have proposed that this process of breakdown contributes to the suboptimal performance of well-learned skills in high-pressure situations (Baumeister, 1984; Beilock & Carr, 2001; Lewis & Linder, 1997). This brings us to Experiment 1, in which we attempted to assess the attentional mechanisms governing the real-time execution of a well-learned golf-putting skill.

Experiment 1

If high-level skill execution is supported by procedural knowledge that does not mandate and, furthermore, may be harmed by continuous online control, then, as demonstrated by Leavitt (1979), Smith and Chamberlin (1992), and Beilock et al. (in press a; b), experienced performers should not be negatively affected by a dual-task environment that draws attention away from the task at hand. In contrast, attending to an explicit component of a well-learned skill may actually serve to disrupt or degrade automated performance procedures. In Experiment 1, experienced golfers performed a golf-putting task in a skill-focused attention condition in which individuals were prompted to attend to a specific component of their performance (i.e., the exact moment that their club head stopped its follow-through) and a dual-task attention condition in which experienced golfers executed the putting task while performing a secondary auditory-tone-monitoring task.

Method

Participants

Participants ($N = 21$) were undergraduate students (7 women, 14 men), ages 18–22 ($M = 19.86$ years, $SD = 0.96$ years), who were enrolled at Michigan State University with 2 or more years of high school varsity golf experience or a Professional Golfers' Association (PGA) handicap less than 8.

Task

Individuals performed the golf-putting task on a carpeted indoor putting green (3 m $\times$ 3.7 m). The task required participants to putt a golf ball as accurately as possible from nine different locations marked by squares of red tape. Three of the locations were 1.2 m, three locations were 1.4 m, and three locations were 1.5 m away from a target, also marked by a square of red tape, on which the ball was supposed to stop. All participants followed the same random alternation of putting from the nine different locations. A standard golf putter and golf ball were supplied. Participants took part in both the skill-focused and the dual-task attention condition.

Skill-focused condition. In the skill-focused condition, participants were instructed to attend to a particular component of their golf-putting swing. Specifically, individuals were instructed to monitor the swing of their club and at the exact moment they finished the follow-through of their swing, bringing the club head to a stop, to say the word "stop" out loud.

Dual-task condition. The dual-task attention condition involved putting while listening to a series of recorded tones being played from a tape recorder. Participants were instructed to monitor the tones carefully and each time they heard a specified target tone to say the word "tone" out loud. The target tone was played three times prior to the start of the dual-task condition to ensure that participants were familiar with this tone. Tones (500 ms each) occurred at a random time period once within every 2-s time interval. The target tone occurred randomly once every four tones. The random placement of the tones within the 2-s time intervals, as well as the random embedding of the target tone within the filler tones, was designed to prevent the golfers from anticipating secondary task tone presentation.

Studies in our laboratory revealed that experienced golfers perform a golf putt (from beginning the initial putt assessment to completing the actual mechanical act of implementing the putt) in roughly 10 s ($M = 10.40$ s, $SD = 1.69$ s, for 420 putts taken by 21 experienced participants). Tones occurred on average once every 2 s, and target tones occurred once every four tone presentations. Thus, individuals received about five tone presentations per putt, including a minimum of one target tone presentation.

Procedure

After giving consent and filling out a demographic sheet concerning previous golf experiences, participants were instructed that the purpose of the study was to examine the accuracy of golf putting over several trials of practice. Participants were set up at the first putting spot and asked whether they preferred to putt right-handed or left-handed. The experimenter informed participants that they would be putting from nine locations on the green. The experimenter then directed participants' attention to a tiny light that had been set up next to each putting spot. Participants were informed that the lights were hooked up to a switchboard controlled by the experimenter. Participants were told that before every putt, a light would illuminate beside the location from which they were to take their next putt. Individuals then performed one set of 20 putts. These putts constituted the practice trials.

The order of the attention conditions was counterbalanced between participants. Individuals performed one set of 20 putts in the dual-task condition and one set of 20 putts in the skill-focused attention condition. Participants were given a short break in between the two attention conditions. Accuracy of putting was measured by the distance in centimeters away from the center of the target that the ball stopped after each putt. The measurement was made by the experimenter while the participant was setting up for the next putt.

Results

Putting Performance

The mean distance from the target of the 20 putts in each condition was used as the measure of performance. In the practice condition, $M = 15.09$ cm ($SD = 3.27$); in the dual-task condition, $M = 13.74$ cm ($SD = 2.65$), and in the skill-focused condition, $M = 19.44$ cm ($SD = 5.42$).

A Bonferroni adjustment was performed on the critical p value of the following comparisons of experienced performers' putting accuracy to guard against inflation of Type I error rates as a result of multiple comparisons. The resulting critical p value was .017. Cohen's d was used as the measure of effect size (for equation, see, Dunlap, Cortina, Vaslow, & Burke, 1996). J. Cohen (1992) suggested that 0.20 is a small effect size, 0.50 is a medium effect size, and 0.80 is a large effect size.

Experienced golfers performed significantly better during the dual-task condition in comparison with the skill-focused condition, $t(20) = 5.22$, $p < .01$, $d = 1.26$. Additionally, putting in the skill-focused condition was significantly less accurate than in the single-task practice condition, $t(20) = 3.94$, $p < .01$, $d = 0.94$, whereas performance in the dual-task condition did not significantly differ from the practice condition, $t(20) = 1.71$, $d = 0.45$. This pattern of results coincides with predictions derived from the skill acquisition and automaticity literature. Specifically, high-level skill execution is thought to be governed by proceduralized knowledge that does not require explicit monitoring and control. Thus, a dual-task environment should not degrade performance in comparison with skill execution under single-task conditions, as attention should be available to allocate to secondary task demands if necessary without detracting from control of the primary skill. The above results demonstrate precisely this notion. It should be noted, however, that these findings may not hold true for dual-task environments in which the tasks draw on similar processes and hence create structural interference (e.g., looking at a golf ball while lining up a putt and visually monitoring a screen for a target object).

Attention Condition Secondary Task Performance

Skill-focused condition. Each trial in which individuals failed to say "stop" at the cessation of their golf swing was recorded. On average, failure to follow instructions occurred in 2.9% of the 20 putts taken in the skill-focused condition by each individual ($M = 0.57$ "stops," $SD = 0.87$ "stops"), or 0.14% of the 420 skill-focused putting trials across all participants.

Dual-task condition. Each instance in which individuals failed to identify a target tone was recorded. Failure to identify target tones occurred infrequently ($M = 0.62$ target tones, $SD = 0.86$ target tones). On average, individuals received 1.25 target tone presentations per putt for a total of 25 target tones per 20 putts taken in the dual-task condition. This led to an error rate of .025 per tone. Given that each participant's errors were distributed over 20 putts, failure to identify a target tone occurred in 3.1% of the 20 putts taken in the dual-task condition by each individual.

Additionally, a significant positive correlation was found between the number of target tone identification errors and our measure of putting accuracy (i.e., mean distance from the target that the ball landed after each putt) in the dual-task condition ($r = .47$, $p < .05$). That is, individuals who performed at a lower accuracy level in the putting task were also more likely to miss identifying a target tone. The fact that individuals with poorer putting accuracy were also less able to identify target tones suggests that putting performance under dual-task conditions was not the result of a simple trade-off between primary putting and secondary tone-monitoring performance. It should be noted that there may be individual differences in performance ability such that certain individuals are less accurate at both putting and secondary task target tone detection. Therefore, the possibility of a more complex trade-off cannot be completely ruled out. However, the positive correlation between putting accuracy error scores and tone detection error rates does suggest that even though average performance was at least as good in the dual-task condition as in the single-task practice condition, there remained a degree of variation in how much attention experienced golfers paid to their putting, which could be detected in accuracy of tone detection. The less accurate the putting was, the greater the amount of attention was paid to it as indexed by decreased accuracy of tone detection.

Finally, a comparison of target tone detection errors between the skill-focused and dual-task condition illustrates that secondary task performance was not significantly affected by our manipulations of attention, $t(20) = 0.21$, $d = 0.05$, *ns*. This observed effect size is substantially smaller than the standard for a small effect size ($d = 0.20$; J. Cohen, 1992), suggesting that if there is a difference in secondary task performance across conditions, it is trivial.

Discussion

The results of Experiment 1 demonstrate that well-learned golf putting does not require constant online control. As a result, attention is available for the processing of secondary task information if necessary (such as monitoring a series of auditory tones). However, when prompted to attend to a specific component of the golf swing, experienced performance degrades in comparison with both single-task practice performance and dual-task conditions. Although the negligible effects of divided attention on well-learned performance have been previously demonstrated (Beilock et al., in press a; b; Leavitt, 1979; Smith & Chamberlin, 1992), the consequences of explicitly attending to automated or proceduralized performance processes have not received so much investigation. The present findings suggest that well-learned performance may actually be compromised by attending to skill execution. This result complements recent evidence on "choking under pressure." Researchers have proposed that pressure to perform at a high level prompts attention to the step-by-step components of a well-learned skill. This attention is thought to disrupt or slow down skill execution, resulting in a less than optimal performance outcome (Baumeister, 1984; Beilock & Carr, 2001; Lewis & Linder, 1997). In the present study, directly instructing experienced golfers to attend to a specific component of their swing produced just this result—a less than optimal performance.

Experiment 2

Experiment 2 was designed to replicate the results of Experiment 1 in a movement skill that uses different effectors and imposes different temporal demands, as well as to examine the effects of dual-task and skill-focused attention on performance at differing levels of skill proficiency. Experiment 1 demonstrated that it can be disadvantageous to explicitly attend to a specific component of an automated or proceduralized well-learned skill performance. However, by analogy to ballistic versus nonballistic movements (Banich, 1997), it might be that explicit attention plays a different role in continuous tasks extended in time, such as soccer dribbling, than in the discrete golf-putting task with a defined beginning and ending point just reported. Furthermore, in addition to task differences, there also may be expertise differences in the impact of attention. Researchers have suggested that close attentional monitoring and attentional control benefits novice performers in the initial stages of task learning (Anderson, 1983; Fitts & Posner, 1967). This notion has received both empirical and anecdotal support (see Curran & Keele, 1993; Proctor & Dutta, 1995). Recently, however, the benefits of attention to specific task components in novel sensorimotor skill performance have been challenged (Singer et al., 1993; Wulf et al., 1998, 2000). Instead, researchers have suggested that instructing novices to attend to task properties during online motor skill performance may actually hinder skill acquisition. Wulf et al. (1998) examined the effects of both an internal focus of attention (defined as attention to specific body movements, much like our skill-focused condition) and an external focus of attention (defined as attention to the effects or outcomes of body movements) on the learning and retention of a ski simulator and stabilometer task. Results demonstrated that an external focus of attention led to more effective learning than an internal focus. Wulf and colleagues proposed that explicitly attending to skill execution at the initial stages of skill learning may actually hinder performance. Thus, a controversy remains over the types of attentional mechanisms thought to support less experienced or less practiced performance processes.

Experiment 2 was designed to assess the attentional mechanisms supporting soccer dribbling performance at different levels of skill proficiency. This was accomplished in two ways: First, the influence of dual-task and skill-focused attention on both novice and experienced soccer dribbling performance was examined. Second, the effects of these attentional manipulations on dominant and nondominant foot performance within soccer skill level were assessed.

If attention to well-learned skill execution disrupts performance, then one might expect explicit attention to experienced performers' dominant right-foot dribbling skill to compromise performance in comparison with dual-task conditions. However, this may not be the case for experienced players' nondominant left foot. That is, although soccer players must be skilled with both feet to compete at a high level, these athletes admit foot preferences and are often more skilled with one foot than with the other (Helsen & Starkes, 1999; Peters, 1981, 1988). Comments from the experienced soccer players in the present study concerning foot preference are consistent with this evidence. For example, one experienced participant stated that in comparison with right-foot dribbling, "dribbling with my left foot is the worst," and another stated that "when I use my left foot performance suffers." As with all introspective reports about task performance, these comments must be viewed with caution. Nevertheless, these comments do indicate that experienced players may not perceive their dominant right-foot and nondominant left-foot dribbling skills as equivalent. If it is true that experienced performers' right- and left-foot dribbling skills do not support the same level of task proficiency, then current theories of automaticity in skilled performance predict that these skills are likely not to be supported by the same attentional mechanisms (Anderson, 1983; Fitts & Posner, 1967; Logan, 1990). Therefore, right- and left-foot performance may be differentially affected by the skill-focused and dual-task attention manipulations in the present study. Put another way, if experienced performers' nondominant foot is not supported by a proceduralized knowledge structure, and explicit attention to less practiced performances serves to enhance skill execution, then in contrast to dominant right-foot dribbling, left-foot performance may actually benefit from explicit attention to skill execution. Similarly, skill-focused attention may lead to a higher level of performance than the dual-task condition for novices, regardless of foot—as novices should not be skilled dribblers with either foot.

In Experiment 2, right-foot dominant novice and experienced soccer players performed a dribbling task in which they dribbled a soccer ball through a slalom course made up of a series of pylons. Individuals performed the task under a dual-task condition involving an auditory word-monitoring task (dual-task condition) and a condition in which individuals were prompted to focus on a specific component of the dribbling task—the side of the foot that last made contact with the ball (skill-focused condition). As with golf putting in Experiment 1, the combination of auditory word monitoring and soccer dribbling should not create structural interference.

Participants took part in both attention conditions while dribbling with their dominant right foot and again while dribbling with their nondominant left foot. The attention and foot manipulations afforded the comparison of dribbling performance between novice and experienced soccer players under the different attentional manipulations in the soccer-dribbling task, as well as within-individual comparisons of dominant and nondominant foot performance.

Method

Participants

Participants ($N = 20$) were self-proclaimed right-handed and right-footed undergraduate students at McMaster University, ages 18–26 ($M = 20.20$ years, $SD = 1.85$ years). The novice participants (8 women, 2 men) had less than 2 years of organized soccer experience ($M = 1.10$ years, $SD = 0.74$ years). The experienced participants (8 women, 2 men) had 8 or more years of competitive soccer experience ($M = 13.30$ years, $SD = 2.75$ years).

Task

Individuals performed the soccer-dribbling task on an indoor gymnasium-type surface. The task required participants to dribble a soccer ball as rapidly as possible through a slalom course that consisted of six cones set 1.5 m apart for a total of 10.5 m from start to finish. Prior to each dribbling trial, participants were instructed to dribble the ball through the cones with either their right foot or their left foot. Individuals were also given instructions concerning the skill-focused and dual-task attention manipulations.

Skill-focused condition. In the skill-focused attention condition, individuals dribbled through the slalom course while a single tone occurred at a random time period on a blank tape once during every 6-s interval. The tone was temporally aligned with the occurrence of the target word in the dual-task condition so that the tone in the skill-focused condition appeared at the same rate as the target word in the dual-task condition. Individuals were instructed to attend to the side of their foot that was in contact with the ball throughout the dribbling trial, so that upon hearing the tone, individuals could verbally indicate whether they had just touched the ball with the outside or inside of their foot. The random placement of the tone was designed to prevent participants from anticipating its occurrence.

Dual-task condition. The dual-task condition involved dribbling through the slalom course while performing a secondary auditory-word-monitoring task. Individuals heard a series of single-syllable concrete nouns spoken from a tape recorder. Words were presented at a random time period once within every 2-s time interval. The target word, *thorn,* occurred randomly, averaging once every three words (6 s). Participants were instructed to monitor the list of words and to repeat the target word out loud every time it was played. The random placement of the words within the 2-s time intervals, as well as the random embedding of the target word within the filler words, was designed to prevent participants from anticipating secondary task word presentation.

Procedure

Participants completed a consent form and demographic sheet detailing previous soccer experience. Individuals were also asked to report their dominant hand and foot. The experimenter further explored individuals' foot preference by asking participants "Which foot would you normally kick a ball with?" This specific question was asked because it is relevant to the predictions made in the present study and is included on several measures of footedness (Day & MacNeilage, 1996; Searleman, 1980). Only those individuals who were self-proclaimed right-handed and right-footed were used.

Participants were instructed that the purpose of the task was to dribble a soccer ball as quickly and accurately as possible through the series of cones set up in front of them. Individuals were also informed that prior to each dribbling attempt, the experimenter would instruct them as to which foot to use. Finally, participants were told that each dribbling trial would be timed by the experimenter. If an error in dribbling performance occurred or the proper foot was not used, the dribbling trial was repeated. This was done to ensure that participants completed the entire slalom course with the specified foot. Because we were interested in making specific predictions concerning the dribbling performance of each foot under the various attentional manipulations, it was extremely important to ensure that participants were solely using the correct foot for each attention condition. Thus, trials containing dribbling errors were repeated. However, errors as a result of failure to use the specified foot were quite infrequent and did not significantly differ across the attention or foot conditions (novice right-foot practice: $M = 0.05$, $SD = 0.22$ errors; both skill-focus and dual-task: $M = 0$ errors; novice left-foot practice, skill-focus, and dual-task: $M = 0$ errors; experienced right-foot practice, skill-focus, and dual-task: $M = 0$ errors; experienced left-foot practice: $M = 0.05$, $SD = 0.22$ errors; skill-focus and dual-task: $M = 0$ errors).

The dependent measure was the time taken to complete each error-free trial, measured with a stopwatch to the nearest tenth of a second. Participants performed two dribbling trials with their right foot only and two dribbling trials with their left foot only. These four dribbling trials constituted the practice trials.

The order of the remaining dribbling trials was counterbalanced between participants. Individuals performed four sets of two dribbling trials (8 total dribbling trials), alternating feet (i.e., right foot only, left foot only) and attentional focus manipulations (i.e., dual-task or skill-focused attention) every two trials. All participants performed the dribbling task with all possible foot and attentional focus combinations. After every two trials in a specific attention condition had been completed, individuals were given a short break during which time they were asked to verbally count backward from 100 by 7s. This manipulation was designed to limit the influence of persisting thoughts about the previous attention condition on subsequent skill performance.

Results

Dribbling Performance

We used the mean of the two error-free dribbling trials performed with each foot under each condition as a measure of dribbling performance for that specific foot and condition. Table 1 presents means and standard deviations for left- and right-foot dribbling performance in the practice, skill-focused, and dual-task attention conditions for both novice and experienced participants. Bonferroni adjustments on the critical p value of dribbling time comparisons in the practice condition were performed to control for the inflation of Type I error rate as a result of multiple between-skill-level and within-skill-level comparisons. The resulting critical p value was .025. The experienced soccer players were significantly faster than novices during practice when instructed to dribble with either their right foot, $F(1, 18) = 52.54$, $p < .01$, $MSE = 1.11$, $d = 3.24$, or their left foot, $F(1, 18) = 13.47$, $p < .01$, $MSE = 3.55$, $d = 1.64$.

Direct comparisons within skill level demonstrated that the novices did not significantly differ in dribbling time between their right and left feet during the practice condition, $t(9) = 1.16$, $d = 0.35$, *ns.* However, this null effect exceeds J. Cohen's (1992) criterion for a small effect size, and thus this nonsignificant result most likely reflects the fact that we do not have adequate power to detect an effect this small. With a medium effect size of 0.50, power is equal to .18 (J. Cohen, 1988). Thus, given the low power of this comparison, it may be unwise to conclude from the lack of a significant difference that the null hypothesis is true.

However, it should be noted that the similarity in dribbling times between novices' right and left feet in the practice condition parallels other findings in our laboratory concerning novel skill performance. In golf putting, for example, novices have been found to putt at a similar accuracy level while using a standard golf putter or an S-shaped and arbitrarily weighted "funny putter" (Beilock & Carr, 2001; Beilock et al., in press a; b). Because novices are not accustomed to performing with either type of putter, the distorted funny putter does not significantly alter their putting accuracy. This is in contrast to experienced golfers, whose performance is degraded by the altered golf putter. In the present dribbling task, novices should not have been accustomed to dribbling with either foot. Thus, despite expressed foot preferences, it may not be too surprising that novices were not significantly more

Table 1
Novice and Experienced Participants' Mean Dribbling Times and Standard Deviations Across Conditions for Both Right and Left Feet

	Condition					
	Practice		Skill-focused		Dual-task	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Novice						
Right foot	10.26	1.29	8.81	1.23	9.70	1.91
Left foot	11.02	2.48	9.30	1.90	10.47	2.04
Experienced						
Right foot	6.85	0.74	8.38	1.23	6.55	0.88
Left foot	7.93	0.97	7.01	0.85	8.21	1.01

skilled with one foot in comparison with the other. However, this was not the case for the experienced soccer players in the present study. Experienced soccer players were significantly faster with their right foot in comparison to their left foot during practice, $t(9) = 2.90$, $p < .03$, $d = 1.25$. This result is consistent with the earlier documented notion that high-level soccer players are often more skilled with one foot than with the other.

Turning to the attention conditions, we performed a 2 (novice, experienced) × 2 (right foot, left foot) × 2 (skill-focused attention, dual-task attention) repeated measures analysis of variance (Table 2). This analysis revealed a main effect of experience, in which the experienced participants dribbled faster than the novice participants across all foot and attention conditions. Furthermore, there was a significant Attention × Expertise interaction and a significant Attention × Foot interaction. However, these two-way interactions are qualified by a significant Experience × Foot × Attention Condition interaction.

In terms of right-foot dribbling, shown in the upper panel of Figure 1, experienced performers were faster than the novices during the dual-task condition ($d = 2.12$). In contrast, experienced and novice participants dribbled at a more similar speed in the skill-focused attention condition ($d = 0.35$). It should be noted, however, that this effect does exceed J. Cohen's (1992) criterion for a small effect size, and thus the similarity in novice and experienced players' right-foot dribbling speed in the skill-focused attention condition should be interpreted with caution. Thus, it is clear that experienced performers were markedly faster than novices in the dual-task condition, whereas in the skill-focused condition their advantage was substantially reduced. Furthermore, experienced soccer players dribbled faster in the dual-task condition in comparison with the skill-focused condition ($d = 1.62$), whereas a tendency toward the opposite pattern occurred in novices, who dribbled faster in the skill-focused condition than in the dual-task condition ($d = 0.56$).

In terms of left-foot dribbling performance, the lower panel of Figure 1 illustrates that experienced performers were faster than novices during both the dual-task condition ($d = 1.40$) and skill-focused condition ($d = 1.56$). Additionally, novice and experienced soccer players performed better in the skill-focused condition than in the dual-task condition ($d = 0.59$ and $d = 1.25$, respectively). Thus, regardless of skill level, in left-foot dribbling, a higher level of performance occurred in the skill-focused condition, designed to draw attention to skill execution, than in the dual-task condition, designed to distract attention away from skill execution. This is in contrast to dominant right-foot dribbling, in which experienced and novice soccer players were differentially affected by the skill-focused and dual-task attention manipulations.

Finally, separate post hoc comparisons of novice and experienced dribbling performance in the attention conditions in contrast to dribbling in the practice condition were performed. Novices' right-foot dribbling during the skill-focused condition was faster

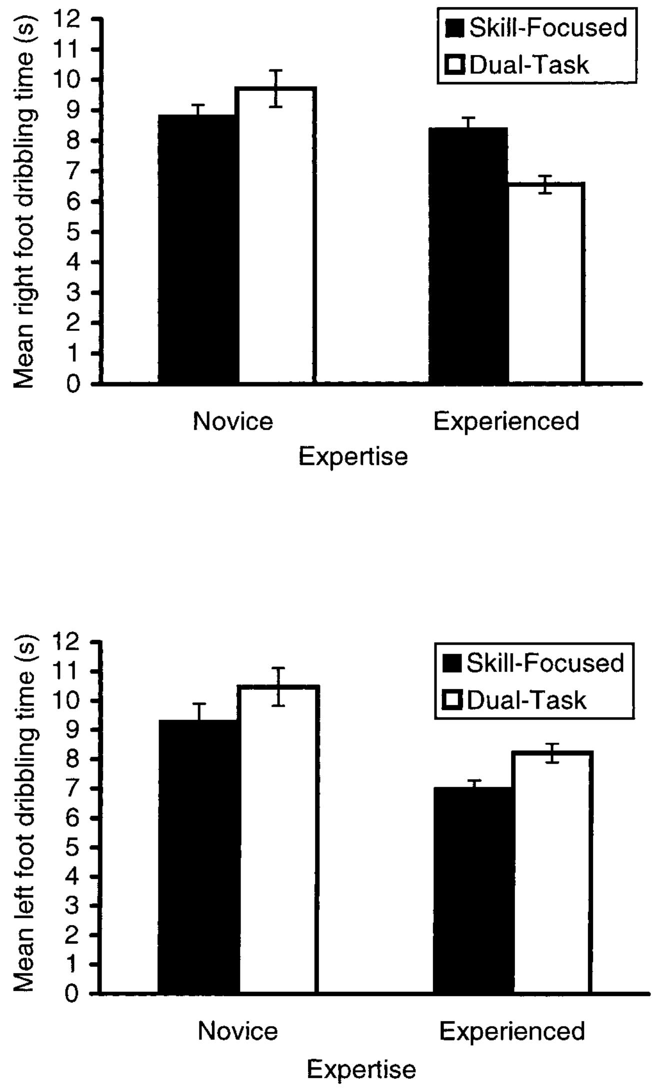

Figure 1. Mean right and left foot dribbling times in the skill-focused and dual-task attention conditions for novice and experienced performers. Error bars represent standard errors.

Table 2
Analysis of Variance for Mean Dribbling Times in the Attention Conditions

Source	*df*	*MS*	*F*	*f*
Between subject				
Experience (E)	1	82.51	17.09**	.558
Error	18	4.83		
Within subject				
Attention condition (A)	1	2.61	1.94	.098
A × E	1	9.02	6.71*	.282
Error (A)	18	1.34		
Foot (F)	1	2.99	2.80	.135
F × E	1	1.92	1.12	.058
Error (F)	18	1.07		
A × F	1	13.67	13.82**	.482
A × F × E	1	9.46	9.56**	.370
Error (A × F)	18	0.99		

Note. Cohen's *f* was used as the measure of effect size (for equation, see J. Cohen, 1988). Cohen suggested that 0.10 is a small effect size, 0.25 is a medium effect size, and 0.40 is a large effect size.
$^{*}p < .05$. $^{**}p < .01$.

than their right-foot practice condition performance (d = 1.19). In contrast, experienced soccer players' right-foot dribbling during the skill-focused condition was slower than their right-foot practice condition performance (d = 1.44). In terms of left-foot performance, both novice and experienced participants dribbled faster during the skill-focused condition in comparison with their respective left-foot practice condition performances (d = 0.76 and d = 1.01, respectively). Thus, although attention to dominant right-foot performance in the skill-focused condition led to an improvement in dribbling speed in comparison with the practice condition for novices, this same condition led to a decrement in experienced soccer players' dribbling skill. With the nondominant left foot, however, both novice and experienced performers improved in dribbling speed from the practice to skill-focused condition.

Attention Condition Secondary Task Performance

Skill-focused condition. On average, novice participants dribbling with their right foot heard 2.80 tones (SD = 0.42), whereas experienced participants heard 2.60 tones (SD = 0.52). During left-foot dribbling, novices heard an average of 2.80 tones (SD = 0.42), whereas experienced players heard 2.10 (SD = 0.32). Each instance in which individuals failed to verbalize the side of the foot that had just touched the ball following tone presentation was recorded. These errors occurred infrequently across both foot and experience level (M = 0.10 foot identifications, SD = 0.31 foot identifications). Overall, there were just two instances of participants failing to verbalize the side of the foot after tone presentation (1 novice and 1 experienced participant in the right-foot dribbling condition). Therefore, analysis of failures to identify the foot that had just touched the ball following tone presentations across foot and experience level was not interpretable because of the infrequency of these errors. Finally, if a skill-focused dribbling condition was completed in which no tones were heard, this trial was counted as an error and repeated. However, this occurred only on one trial across all participants (a novice right-foot dribbling trial).

Dual-task condition. On average, novice participants heard 5.30 words (SD = 0.82; M = 2.90 target words, SD = 0.32) while dribbling with their right foot, whereas experienced participants heard 3.80 words (SD = 0.63; M = 2.10 target words, SD = 0.32). In terms of left-foot dribbling, novices heard an average of 5.6 words (SD = 1.08; M = 2.90 target words, SD = 0.32), whereas experienced players heard 4.60 words (SD = 0.70; M = 2.50 target words, SD = 0.53). Each instance in which individuals failed to identify a target word was recorded. As in the skill-focused condition, errors were infrequent (M = 0.20 target words, SD = 0.41 target words). There were five instances of failure to identify a target word across both foot and expertise level (three target word identification failures in novice right-foot dribbling, one target identification failure in experienced right-foot dribbling, and one target identification failure in novice left-foot dribbling). Analysis of target identification differences across foot and experience level was not interpretable because of the infrequency of these errors. Thus, similar to Experiment 1, errors in secondary task performance were infrequent across both attention condition and level of expertise.

Discussion

The purpose of Experiment 2 was to explore differences in the attentional mechanisms supporting online sensorimotor skill execution in novice and experienced soccer players, as well as to assess differences in the attentional requirements of dominant and nondominant foot performance within level of expertise. Theories of skill acquisition have proposed that distinct cognitive processes are involved at different stages of skill execution. Early in learning, individuals are thought to attend to the step-by-step processes of performance. However, once a high level of performance has been achieved, constant online attentional control may not be necessary (Anderson, 1983, 1993; Fitts & Posner, 1967; Logan, 1988). One could infer from this framework of skill acquisition that novices might benefit from conditions that prompt attention to task properties yet not profit to the same extent in environments that divert attention away from the primary task at hand. In contrast, experienced performers may be harmed by explicit attention to skill processes that normally run as uninterrupted programs or procedures, yet they may not be adversely affected by conditions that draw attention away from performance. However, this may hold true only for those aspects of an experienced performer's skill execution repertoire that are indeed governed by a proceduralized or automated knowledge representation. If particular aspects of a skill are not as well learned or as highly accomplished, then experienced individuals—like less practiced performers—may benefit more from conditions that prompt attention to the task at hand rather than take it away.

The results of the present study conform quite well to these predictions derived from theories of skill acquisition. For right-foot dribbling, novices performed at a lower level in the dual-task condition, designed to distract attention from task performance, in comparison with the skill-focused manipulation, designed to draw attention toward the task at hand. Furthermore, novices substantially improved in dribbling speed from the single-task practice condition to the skill-focused condition. Experienced soccer players showed an opposite pattern of results. Experienced individuals performed at a lower level in the skill-focused condition compared with either the dual-task or practice condition. These results coincide with those of Experiment 1 and, as mentioned above, are consistent with current theories of choking under pressure (Beilock & Carr, 2001).

Performance with the left foot differed. In contrast to right-foot dribbling, novice and experienced soccer players alike performed better in the skill-focused condition than in the dual-task or practice condition. In the present study, there were significant differences in experienced performers' right- and left-foot dribbling speed in the practice trials. This pattern of results suggests that experienced players' left-foot dribbling skill was not at the same performance level as their dominant right-foot skill. The fact that the differential impact of the attentional manipulations in the present study was evident not only between skill levels but within experienced performers' dominant and nondominant feet performance as well speaks to the robust nature of the impact of attention on skill performance.

General Discussion

When Attention to Performance Becomes Counterproductive

The findings of Experiments 1 and 2 demonstrate that skill-focused attention benefits less practiced and less proficient performances yet hinders performance at higher levels of skill execution. High-level skills are thought to become proceduralized or automated with extended practice. The encoding of task components in a proceduralized form supports effective real-time performance, without the need for constant online control. As a result, skill performance decrements occur in conditions that impose step-by-step monitoring and control on complex, procedural knowledge that would have operated more automatically and efficiently had such monitoring not intervened. Therefore, experienced performers suffer more than novices from conditions that call their attention to individual task components or elicit step-by-step monitoring and control. However, experienced performers are better able than novices to spare a portion of their attention for other stimuli and task demands, and hence are better able than novices to deal with conditions that create dual-task environments (e.g., taking a series of golf putts or dribbling a soccer ball while performing an auditory-monitoring task). As shown by the contrast between right-foot and left-foot dribbling, however, this may hold only for that portion of an experienced performers' skill repertoire that is supported heavily by proceduralized knowledge structures.

The findings of the present study confirm results generated in Leavitt's (1979) hockey study, Smith and Chamberlin's (1992) soccer-dribbling task, and Beilock et al.'s (in press a; b) golf-putting study. Furthermore, the present findings expand previous results by examining the consequences of explicitly attending to both novel and well-learned performances. Researchers have recently suggested that attention to the step-by-step components of a novel skill may be detrimental to performance (Singer et al., 1993; Wulf et al., 1998, 2000). However, the present findings demonstrate that attention benefits both novel skill performance and performance that is not based on a heavily proceduralized knowledge representation, even though carried out by an experienced performer (e.g., experienced soccer players' nondominant foot performance). In contrast, at higher levels of learning and proficiency, increased attention to the step-by-step execution of a well-learned skill appears to have the opposite effect—disrupting skill execution processes.

It should be noted that the present study examined the performance of a golf-putting task and a soccer-dribbling skill under different attentional manipulations at approximately constant levels of performance, rather than examining the learning or transfer of these skills to novel task situations. For this reason it remains possible that under conditions commonly used to assess skill learning (e.g., transfer tests), a different pattern of performance may arise. Future research in this area would serve to shed light on this issue.

Not All Forms of Attention Are Counterproductive to Well-Learned Skill Performance

The above mentioned results indicate that attention to step-by-step skill execution—what we term *skill-focused attention*—may benefit novel performances yet hinder well-learned and highly proficient task execution. However, this relationship may not extend to other forms of attention to task-related information. R. Kanfer and Ackerman (1989) demonstrated that "self-regulatory" activities, including the allocation of attention to performance outcomes and goal attainment, self-evaluation, and self-reactions, detract from the lower level performances of novices yet enhance skill execution at later stages of learning and higher levels of proficiency. Self-regulatory activities are thought to require attentional capacity for successful initiation and implementation. Thus, self-regulation may disrupt novel skill execution by recruiting attentional resources needed for control of task performance (F. H. Kanfer & Stevenson, 1985). However, this may not be the case for more experienced performance that does not rely on constant attentional control. Instead, self-regulatory functions may be implementable in parallel with proceduralized control processes, serving to store information about the outcomes and evaluations of performance (rather than the unfolding of their step-by-step components) that is needed for subsequent cognitions about ones' abilities, effort, and strategies for task control (R. Kanfer & Ackerman, 1989; Kluwe, 1987). We propose, then, that self-regulatory attention and skill-focused attention differ in a crucial way: Self-regulatory attention is metacognitive and aimed at the plans that precede skill execution and the products that follow skill execution (Brown, 1987), whereas skill-focused attention is cognitive and aimed at the component steps that constitute execution itself (Beilock & Carr, 2001).

If attention devoted to self-regulation is different from skill focus yet depends on some of the same attentional resources, then self-regulatory activities may provide a secondary, unintended benefit to experienced skill execution: Specifically, self-regulation applied to the plans, the outcomes, and the feelings accompanying performance may prevent individuals from paying too much attention to the step-by-step control of that performance as it unfolds in real time. It may be that individuals involved in self-regulatory functions do not have the resources available to explicitly attend to, monitor, or try to control particular steps or components of online performance—a practice that was shown in the present study to disrupt high-level execution. Thus, although explicit attention to component steps of proceduralized performances may disrupt or dismantle optimal task execution at high levels of learning and proficiency, attentional processes that serve higher level, more metacognitive roles may instead promote optimal performance, both by focusing attention on plans and outcomes and also by preventing attention from focusing on step-by-step control of execution.

Furthermore, skill-focused attention may not always be detrimental to well-learned performances. The present study demonstrated that skill-focused attention applied to current real-time performance disrupts execution. However, if applied in other circumstances, such as practice situations, in which performers are consciously attempting to dismantle their skill and modify certain parts in accord with data collected by self-regulatory activities such as those mentioned above, skill-focused attention may actually be helpful. That is, when the goal is not to maximize real-time performance but instead to explicitly alter or change performance processes to achieve a different outcome, skill-focused attention may be beneficial. In this manner, skill-focused attention may become embedded in the metacognitive activities of self-regulation. Specifically, individuals may attend to specific components of their skill (i.e., implement skill-focused attention) to alter control strategies and execution processes that, through self-regulatory actions, have been deemed unproductive or maladaptive to progress toward a desired goal state. Although this monitoring of performance may be temporarily detrimental to skill execution, as performers will most likely have to slow down and break down previous execution procedures to attend to and alter these processes, and then readapt to and proceduralize the new execution parameters, ultimately these changes should produce performance benefits as skill execution becomes more closely aligned with desired outcomes.

Implications for Skill Training and Performance

Coaches and teachers have long believed that different teaching styles are required at various stages of learning to address the changing attentional mechanisms of the performer. The findings of the present study begin to lend empirical support to this notion. For example, the results of the present study suggest that it may be beneficial to direct performers' attention to step-by-step components of a skill in the early stages of acquisition. This might be achieved through instructions that draw learners' attention to task-relevant kinesthetic or perceptual cues. However, at later stages of performance, this type of attentional control may be detrimental, at least in situations where maximum performance is the desired real-time outcome. In the present study, experienced golfers and soccer players showed decrements in performance under conditions designed to prompt attention to step-by-step execution. Thus, it may be beneficial for experienced individuals to allocate attention to aspects of performance that are not directly involved in the online control of skill execution. McPherson (2000) demonstrated that successful, experienced tennis players spend a significant amount of time examining their own performance outcomes, as well as those of their opponents, as a tool for diagnosing and updating performance strategies and maintaining focus on the task at hand. At higher levels of practice, then, when attention may not be necessary for the online control of performance, such functions as strategizing about choices of actions not only may help to achieve desired goal-states but also may prevent individuals from over attending to well-learned performance processes and procedures.

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